STEAM VESSELS

THE NATIONAL BOILER AND GENERAL INSURANCE COMPANY LIMITED
MANCHESTER

The National Boiler and General Insurance Co. Ltd.

Head Offices.

National Buildings, St. Mary's Parsonage,
MANCHESTER.

Notes on the

Design, Construction and Working of vessels subjected to Steam Pressure.

Manchester:
BETHELL & CO. LTD.

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Steam Vessels.

A large and continually increasing number of trades use steam for one process or another in their manufacturing operations. Steam is of course, regularly used by Chemical Manufacturers, Soap Makers and Brewers, and in Paper Works and Bleaching and Dyeworks, where the process carried out is on a comparatively large scale. Also in recent years, the use of steam has been found advantageous and economical in a number of other trades and at the present time steam is used by Bakers and Confectioners for baking bread and boiling sugar, by Clothing Manufacturers for pressing, in all kinds of Laundry operations, by Hospitals, Workhouses and Institutions for cooking, warming, disinfecting and so forth, as well as in a large number of other businesses, such as Dairies, Biscuit Manufacturers, etc. **Use of Steam in Manufacturing Operations**

The Vessels in which steam is employed for manufacturing purposes vary greatly in size and shape, as well as in the working pressure which has to be withstood. In some cases the material to be treated is brought into actual contact with steam in the vessels as in kiers and rag boilers, while in another class of vessel steam is employed for heating purposes indirectly, as in jacketed pans, hot tables and steam jacketed vessels.

The following notes deal with such vessels principally from the point of view of safety as regards the use of steam under pressure, and it is hoped that they will prove of service to insurers and makers of such apparatus.

INSPECTION

These vessels, in all cases, should have the same regular service of inspection as in the case of steam boilers. They are subject to similar causes of deterioration, such as internal and external corrosion, and in addition generally require special attention to the protective arrangements requisite to prevent over-pressure. See page ii for particulars of the "National" Company's Service of Inspection and Insurance of Steam Vessels.

STEAM PIPES AND CONNECTIONS.

STEAM PIPES AND CONNECTIONS

Those cases in which steam vessels are strong enough to withstand the full boiler pressure are the exception and in most plants it is necessary to protect the vessels against possibility of over-pressure.

Safety Valves on Vessels.

In many cases a safety valve fitted on the vessel itself is useless, as the material being treated in the vessel is either of a sticky or viscous nature, which would cause the safety valve to stick, or else is so corrosive as to eat away the valve seats or cause the valve to rust fast. For these reasons usually the safety valve should be fitted on the connecting pipe and not on the vessel.

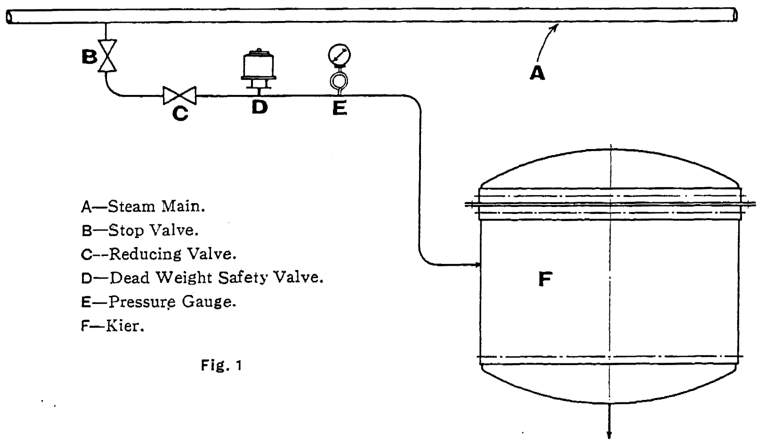
Safety Valve on Low Pressure Steam Pipe.

The steam from High Pressure Boilers is frequently reduced in pressure by passing it through a Reducing Valve and in such cases in addition to the Reducing Valve it is necessary to have a safety valve on the low pressure pipe to prevent pressure from accumulating when little or no flow is taking place. The safety valve should preferably be of the dead weight pattern with testing lever and it should be fitted sufficiently far from the Reducing Valve to ensure that a steady pressure is obtained.

Stop Valve.

In addition to a reducing valve and safety valve it is necessary to have a stop valve in the branch pipe leading to low pressure vessels, so that steam may be shut off altogether

when not required, and there should also be a pressure gauge on the low pressure pipes. The arrangement of fittings where steam is being supplied to a single low pressure vessel will therefore usually be as shown in Fig. 1. Where, however, **Pressure Gauge.**



A—Steam Main.
B—Stop Valve.
C—Reducing Valve.
D—Dead Weight Safety Valve.
E—Pressure Gauge.
F—Kier.

Fig. 1

steam is supplied to a number of vessels in which material is boiled by steam, such as kiers or rag boilers, it is necessary, in addition to the fittings mentioned above to have a non-return valve in the branch to each kier or rag boiler, and an air valve to prevent a vacuum forming after steam is shut off. It has sometimes happened that on the plant cooling down a vacuum has been formed in the steam pipe, with the result that material from the vessel has been sucked back along the pipe and choked the safety valve. As a further safeguard against this happening it is often advisable to fit a large separator in the steam pipe to act as a trap and prevent any material which might be drawn along the pipe from reaching the safety valve or reducing valve. Fig. 2 shows a satisfactory design of separator for this purpose. The drain pipe leading to a steam trap is placed well above the bottom and dips below the water level where it is unlikely to become

Non-return Valve. **Air Valve.** **Separator.** **Design of Separator.**

clogged with scum or fluff. A large hand blow-out is also fitted in the bottom which is itself removable for cleaning.

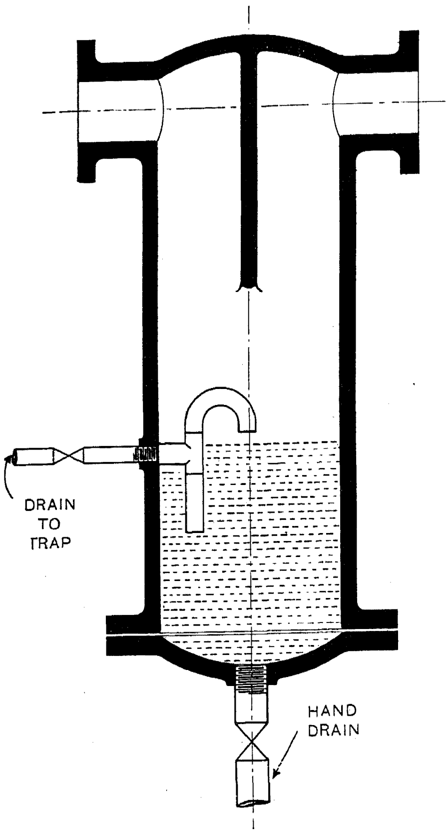


Fig. 2

Arrangement of Steam Connection to Rag Boilers.

The complete arrangement of fittings for a series of low pressure rag boilers is shown in Fig. 3. The function of the non-return valves G is to prevent the possibility of material being drawn out of one vessel into another. This sometimes happens when steam is first turned into a cold vessel and adjacent vessels are already heated up. The great rush of steam into

the cold vessel and the reduction of pressure due to condensation has a tendency to draw material out of the heated vessels.

Size of Steam Pipes for Reduced Pressure.

Objection is sometimes raised to fitting a reducing valve in the steam supply pipe to kiers on the ground that the time taken to heat up the kiers is thereby increased. A large volume of steam is required when first boiling up and in many of those cases where difficulty has been experienced

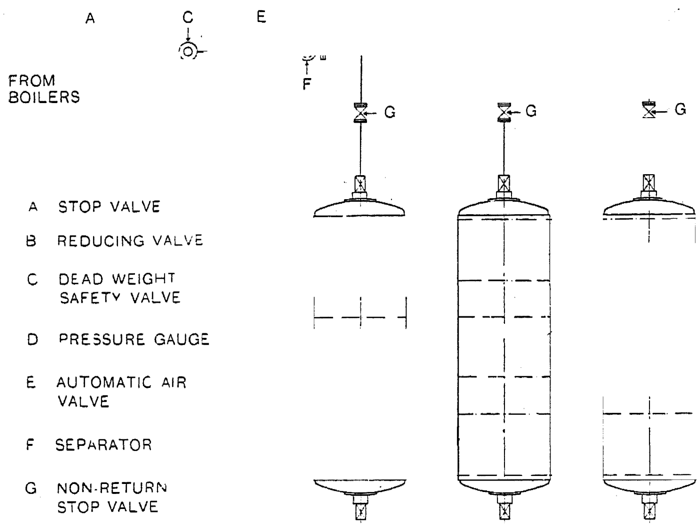


Fig. 3

the cause has lain not with the reduction in pressure, but with the size of steam pipe which has been insufficient to pass the required volume of steam at the reduced pressure. Reduction in pressure, is, of course, accompanied by increase in volume, and if the high pressure steam pipe leading to the reducing valve is only just large enough to pass the required weight of steam it is necessary to increase the size of pipe on the low pressure side if the maximum rate of supply to the kiers is to be maintained.

Size of Safety Valve for Low Pressures.

The same fact must be taken into consideration when fixing the size of safety valve, the capacity of which should be sufficient to discharge all the steam which the reducing valve will pass, at the reduced pressure. This will frequently mean that a larger safety valve is required on the low pressure pipe than is necessary on the boiler or on the high pressure range.

Reducing Valves.

Reducing Valves.

Action of Simple Reducing Valve.

In the simple types of Reducing Valves reduction in pressure is effected by causing the steam to pass through a valve which is in equilibrium on the inlet side and which, on the outlet side, is closed by the reduced pressure steam acting against springs. The tendency of the springs is to open the valve as long as the pressure on the reduced pressure side does not exceed that for which the valve is adjusted. Consequently there is always a flow of steam from the high pressure to the reduced pressure side until the pressure rises to the desired point when the valve closes and no further flow takes place until pressure again falls.

Requirements for Reducing Valve for Vessels.

A simple Reducing Valve of this kind works very well as long as the flow of steam is fairly steady, but the supply of low pressure steam to such Vessels as Kiers and Rag Boilers usually fluctuates greatly, at times all the steam which the pipe can carry being required and at other times the flow ceasing altogether. Under such conditions the simple type of Reducing Valves is not suitable as it does not give a sufficiently wide opening to steam on the one hand while on the other hand when the flow of steam ceases the valve is only resting on its seat without effective pressure closing it and there is consequently a tendency for pressure to leak past and accumulate on the low pressure side.

Another difficulty with Reducing Valves of this type and one which increases the liability to accumulation of pressure when little steam is being used, is the impossibility of keeping the valve and seat in a condition in which steam tightness can be assured. A valve which acts by throttling is liable to cutting and erosion of the valve and seat owing to the small amount of lift usually obtained.

For the purpose of supplying reduced pressure steam to Vessels therefore a Reducing Valve of special type is generally desirable, such valves being designed to give increased opening to steam and an effective pressure on the valve to close it when no flow is taking place.

Several patterns of Reducing Valves are shown in Figs. 4, 5 and 6 and described below.

Royles' 1902 Pattern Reducing Valve

Fig. 4 illustrates one pattern of Royles' Reducing Valves. In this design an elastic tube B and a series of rings C.C. are used to balance the pressure on the underside of the valve A and so to place the valve in equilibrium with respect to steam pressure on the inlet side. The tube with its surrounding rings is in effect an elastic cylinder, the bottom end of the casing acting as a piston; it is claimed that the movement is frictionless as the piston does not move in the cylinder, the body of the cylinder itself elongates.

Two external springs D.D. connected to the casing E., give the valve a tendency to open which is resisted by the reduced pressure on the top of the valve. The tension in these springs, therefore, determines the reduced pressure.

The other ends of the springs are connected to a yoke F which loads a safety valve G. As the area of the safety valve is about 20% less than the area of the valve A the

safety valve will lift if the pressure on the low-pressure side should exceed by 20% that for which the reducing valve is set. A ferrule H limits the pressure to which the safety valve can be loaded.

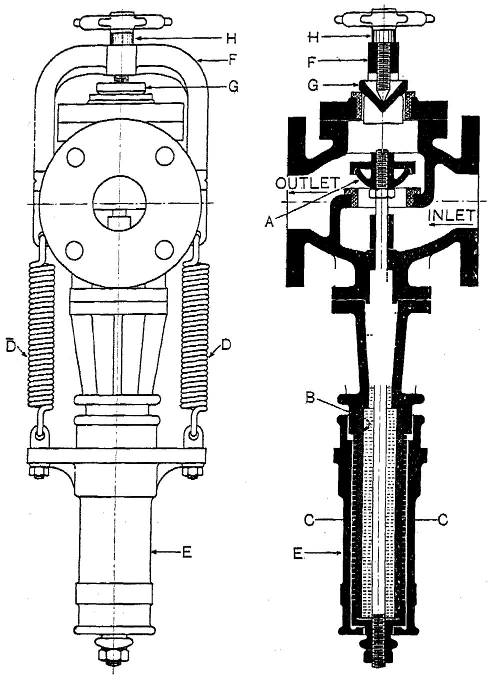
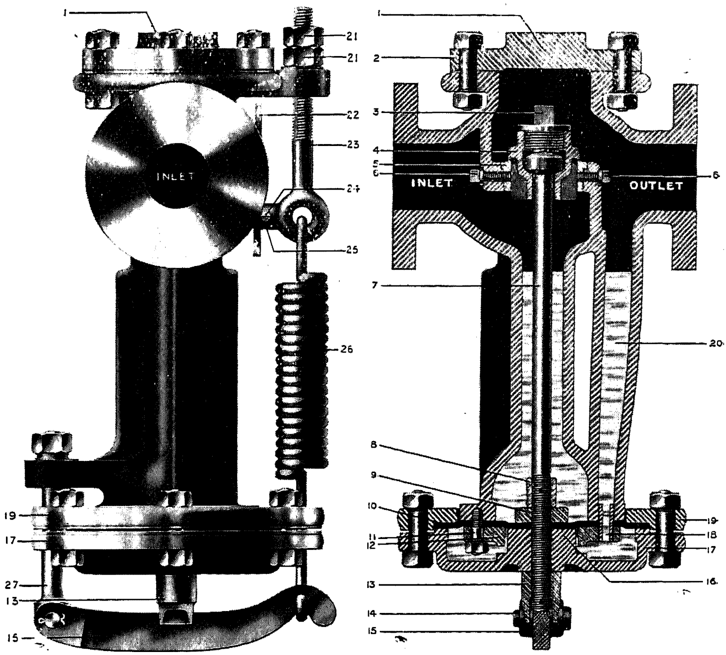


Fig. 4.

Auld's Reducing Valve

The latest form of Auld's Reducing Valve is illustrated in Fig. 5. On the inlet, or high pressure side, the valve is maintained in equilibrium by the steam pressure which acts


INLET
INLET
OUTLET
1
2
3
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26
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Fig. 5.

between valve (4) and piston (16) of the same effective area, and at the other end of spindle ; this piston (16) being a loose fit and covered by flexible disc (10) to prevent leakage. The valve (4) is opened by means of spring (26) acting through lever (15), and the reduced pressure steam acting on top of valve (4), and in cup (17), into which it passes through

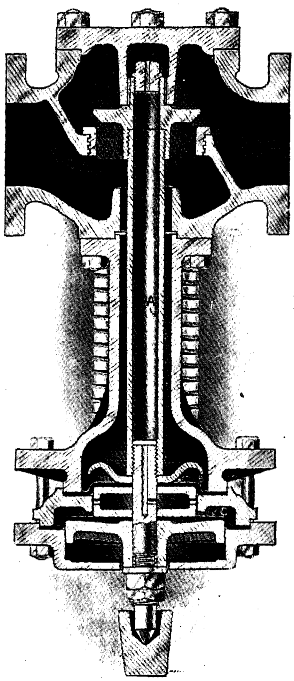

Fig. 6.

port (20), counterbalances the force exerted by the spring. Consequently any tendency of the reduced pressure to vary not only acts on top of valve (4) (being the only effective force in the original type of valves), but also acts on the considerably greater area in cup (17), so that the sensitiveness of the valve is increased and steadier regulation of pressure

ensured. The reduced pressure can be regulated by means of adjusting nuts (21), and a suitable index is provided showing range of regulation.

Dewrance Double Control Reducing Valve

Fig. 6 shows Dewrance & Co.'s "Double Control" Reducing Valve. The distinctive feature of this valve is that there are two diaphragms, a small one B to balance the valve so that it is independent of variations in the initial pressure, and a large one C which provides a margin of power to control the valve. This feature ensures that the valve is sensitive to any variations in the reduced pressure, and that when the flow is stopped there is an effective force on the valve holding it closed.

VESSELS.

VESSELS.

In the following pages there are described a number of vessels used in various manufacturing processes. Such vessels are subject to considerable wear and tear, and the experience of the "National" Company shows that in many cases the nature of the process is such as to cause rapid wasting of the plates and general deterioration, both internal and external.

Internal Corrosion.

Many vessels are used for treating materials of an acid nature, or a weak solution of acid is employed in the process, and in this class of vessel internal corrosion is very rapid, necessitating close and careful inspection.

Types of Corrosion.

Corrosion of steel or iron plates takes the form, in some cases, of general smooth wasting, and in others of local pitting. These two forms of corrosion are shown in the photographs reproduced in Fig. 7. The upper plate is generally wasted from the lap edge and the thickness of the plate seriously reduced all over. The lower plate in the photograph is not generally reduced in thickness to a material extent, but deep local pittings occur.

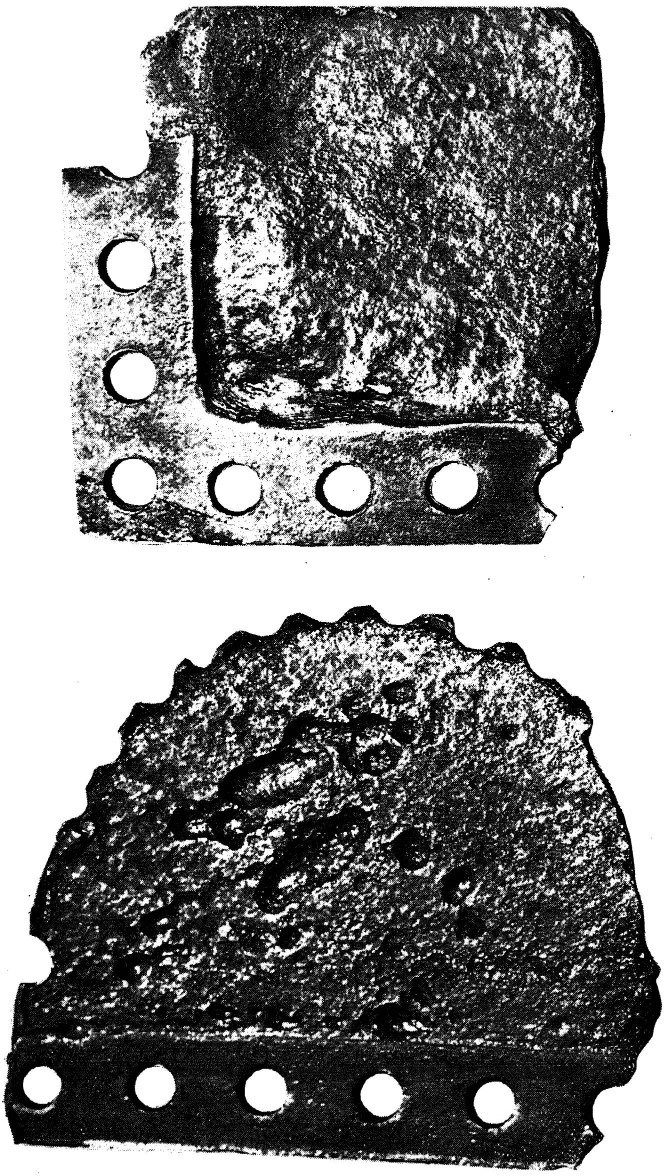

Fig. 7

Types of Corrosion.—Smooth Wasting.
Pitting.

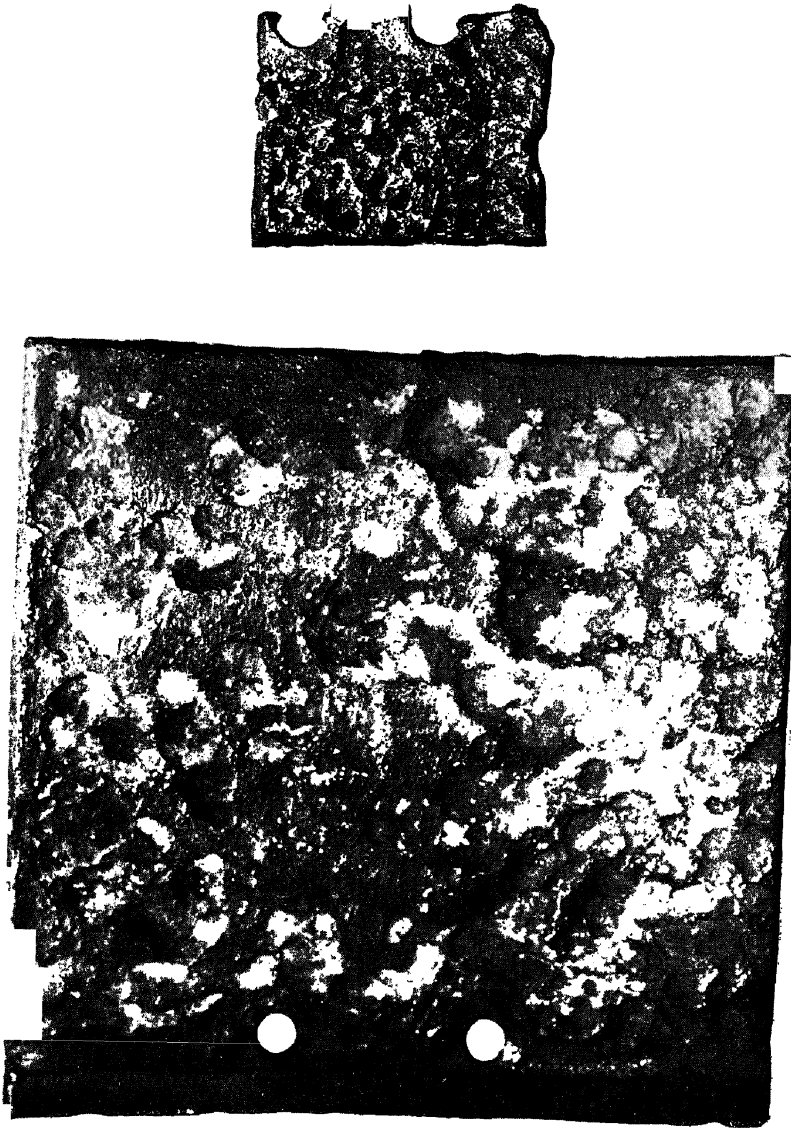

Fig. 8

Types of Corrosion.—Honeycomb Pitting.
General Wasting.

Fig. 9

Example of Wasting and Fracture at Lap Edge.

Photographs of two other examples of corrosion are shown in Fig. 8. The small plate at the top is an example of severe "honeycomb" pitting.

Fig. 9 shows severe wasting at the edge of a lap seam. Rivet heads and plates are generally wasted to a severe extent, and this wasting, combined with the bending action which takes place at the edge of a lap joint, has resulted in the plate fracturing along the lap edge.

After a vessel has been scraped and prepared for inspection, the plates internally are often still covered with a film of dried greasy deposit, and the vessel, including the seams and rivets, may on casual inspection appear to be in good condition. Drilling, however, may show the body of the plates to be uniformly wasted, or, while the body of the plates may be good, careful scraping with a knife or sharp tool may remove deposit consisting of grease and oxide from underneath the heads of the rivets and right into the underlaps of the ring and longitudinal seams, as indicated in Fig. 10. In some cases this wasting has proceeded at the rate of 1/32 inch to 3/16 inch in twelve months. In many cases cast iron more successfully resists corrosive action than steel or wrought iron.

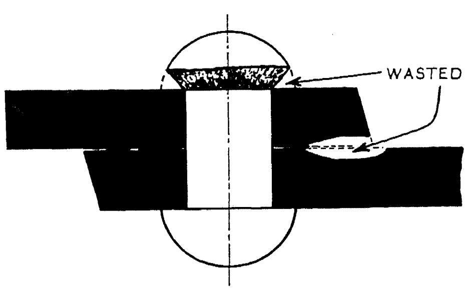

Fig. 10

A considerable number of steam jacketed vessels, such as ironing machines, hot presses and low pressure jacketed pans are constructed of cast iron, but the greater number of Design of Steam Vessels.

steam vessels are built of wrought iron or steel plates, and their design follows the same general lines as the design of steam boilers. Such vessels are for the most part cylindrical in shape, with flat or dished ends, the strength of which to withstand internal pressure can be calculated by the Boiler Rules given in "Steam Boiler Construction." * In most cases, however, a larger factor of safety must be adopted than is necessary when designing boilers, owing to the increased liability of such vessels to internal corrosion and the greater wear and tear to which they are subjected.

Allowance for Wear and Tear.

Large Openings.

Another respect in which such vessels differ from steam boilers is in the necessity for large openings by which the material to be treated can be introduced. Such large openings tend to weaken the cylindrical shell and make the problem of compensating for the part cut out a somewhat difficult one. The design of such large covers and of the joints by which they are bolted to the shell again are problems somewhat different from any which arise in ordinary boiler design. In many vertical kiers the whole end is removable for access, and as the bolts by which the joint is made are screwed and unscrewed every time the vessel is charged the wear and tear on bolts and nuts is very severe.

Covers.

Stirrers.

Many vessels are fitted with internal stirrers or agitators by which the contents are kept in motion while boiling or whilst being acted upon by steam. This continual movement of the material over the plates results in considerably increased wear at certain points, and consequently the allowance for wear which is satisfactory for steam boilers would not be sufficient for such vessels as rag boilers, autoclaves or converters.

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* "Steam Boiler Construction." Revised 1920.
The National Boiler and General Insurance Company Ltd., Manchester.

All vessels using steam require to be protected against risk of over-pressure, and in many cases it is a more difficult matter to ensure the safety of a vessel than of the boiler to which it is connected. For one thing, the vessel is commonly used and operated by persons without engineering knowledge, and very often the arrangements for systematic inspection stop short at the boiler, instead of applying to all plant in which steam is used. The most serious cause of accident, however, arises from the fact that these vessels frequently work at a considerably lower pressure than the boiler to which they are connected, in which case the problem of safeguarding them against over-pressure is one which requires careful consideration and expert knowledge.

Protection Against Over-Pressure.

The Boiler Explosions Acts 1882 and 1890, which require that when an explosion occurs the owner or user of the boiler shall send notice to the Board of Trade, give a wide definition of the term "Boiler," and include all classes of steam boilers, hot water boilers, and *Vessels in which steam is used.* These Acts, therefore, apply to steam pipes, steam receivers, kiers, jacketed pans, stills, ironing machines, bone boilers, disinfectors and all such apparatus.

Boiler Explosions Acts.

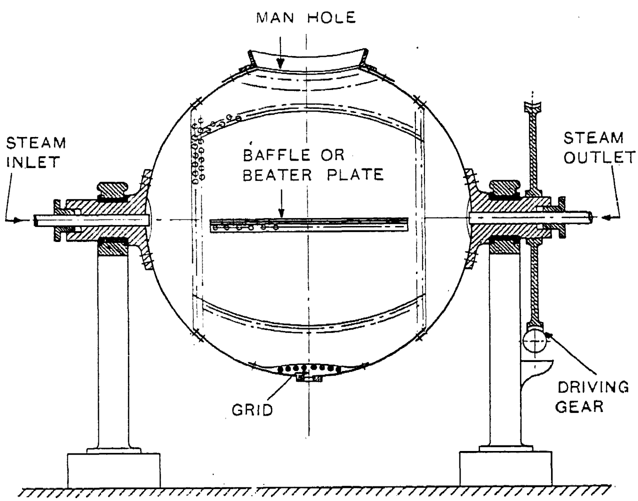
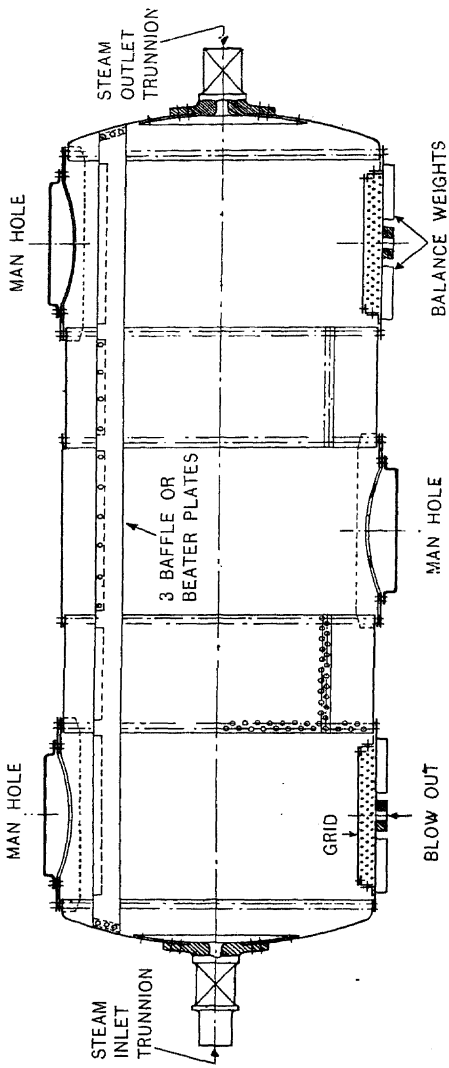


Fig. 11

The NATIONAL Boiler and General Insurance Co. Limited, Manchester.


STEAM OUTLET TRUNNION
MAN HOLE
BALANCE WEIGHTS
3 BAFFLE OR BEATER PLATES
MAN HOLE
MAN HOLE
GRID
BLOW OUT
STEAM INLET TRUNNION

Rag Boilers.

Figs. 11 and 12 show two forms of rag boilers, Fig. 11 being the old-fashioned spherical vessel, and Fig. 12 a modern design of cylindrical rag boiler with dished ends. Such vessels are largely used for boiling up rags or grass in the manufacture of paper pulp. When charged with material the man-hole is closed and steam admitted through one of the trunnions while the vessel is revolved. RAG BOILERS.

Owing to the vessels being supported on the trunnions a considerable strain is thrown on the end plates and some movement takes place round the trunnion connections. This strain combined with the movement produces conditions favourable to the formation of cracks and grooves, and in practice severe grooving of the kind shown in Fig. 13 is a common defect in rag boilers. Grooving in Rag Boilers.

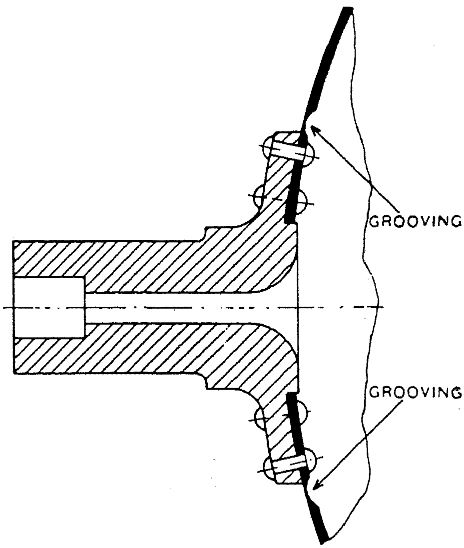


Fig. 13

In modern designs the end plate, at the part where the trunnion is attached, is stiffened by means of a doubling plate,

and in this way the movement and consequent tendency to grooving are minimised. In the case of older vessels it is often practicable to take the weight on rollers as indicated in Fig. 14 and this, of course, is an effective way of preventing grooving in the end plates. A hoop is riveted to the shell at one or more points in the length and this hoop runs on rollers revolving freely in adjustable bearings.

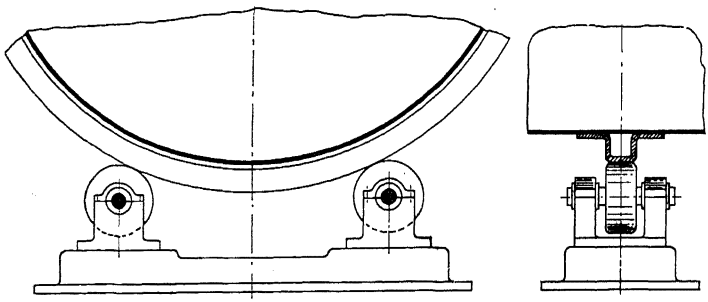


Fig. 14

Kiers.

KIERS.

Kiers are large cylindrical vessels in which cloth and other materials are treated under the action of steam. An important feature in the design of such vessels is the manhole or opening through which the cloth is put in and removed. These openings are of large size, consisting in many cases of a removable end cover of the full size of the kier and the method of securing such large covers calls for careful consideration.

Covers of Kiers.

The usual method of securing such covers is to use a number of hinged bolts which drop into slots in the flange of the cover; when the cover is to be lifted the nuts are slackened back and the bolts allowed to fall out of the way. It is necessary for the cover to be as stiff as possible near the edge, so that it may withstand the strain of tightening up the joint, otherwise the flange springs at the edges and there is a tendency for the nuts to slip off. A number of serious accidents have occurred as the result of the nuts slipping over the edge of the flange from this cause.

If existing covers are weak at the flange they may often be strengthened by riveting on a reinforcing plate as shown in Fig. 15. The bolts must not be placed too near the edge of the flange, as that increases the risk of the nuts slipping off ; another important point is to avoid the use of an unnecessarily thick packing.

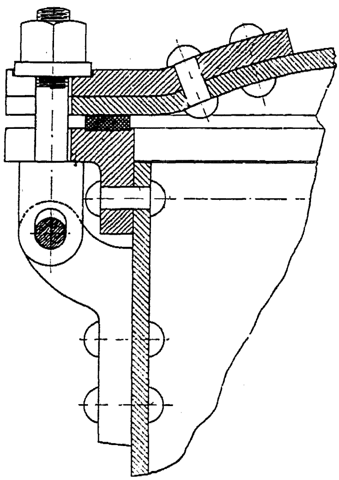


Fig. 15

Wear on Cover Bolts.

It must be remembered that such covers are fastened and unfastened much more frequently than is the manhole cover of a boiler, and the wear on bolts and nuts is consequently much greater. Specially deep nuts are therefore required and the fit of bolts and nuts in the thread is very important.

Methods of Preventing Nuts from Slipping over Flange.

In addition to ensuring that the flange is amply stiff at the edge to resist springing when the bolts are tightened, it is necessary to take further precautions against the tendency for the nuts to slip over the edge of the slots and three different arrangements are shown in Fig. 16 at A, B and C. A shows a spherical washer which fits in a recess in the flange. B a flat washer and flat knifed recess, while C shows a bead on the flange, and a plain flat washer.

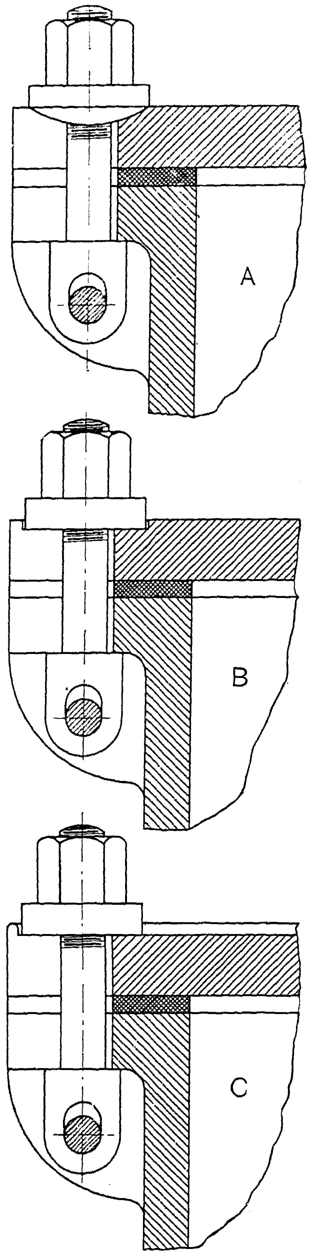


Fig. 16

With each of these arrangements the washer is only supported for about three-quarters of its circumference, and ordinary thin washers therefore are useless, as they would bend severely; thick washers about ½ inch deep must be used.

Kiers belong to a class of plant which is often subjected to very rough handling, and requires in consequence to be of robust design if it is to stand up to its daily working conditions. It is a common fault with workmen when opening such kiers only partially to slacken back the nuts, and then to knock them over the flange with a hammer. This, of course, has the effect of rounding the edge of the flange and the bottom of the nut, which is most objectionable, as it increases the tendency for the nut to take up a position, when it is being tightened, in which it will be likely to slip over the flange. Another reprehensible practice, but one which is very commonly followed, is to tighten up alternate bolts only and to hammer these up very tight; this throws an undue strain on half the bolts and increases the liability of leakage owing to the pitch of the bolts being too great.

Digesters, Concentrators, etc.

DIGESTERS, CONCENTRATORS.

Figs. 17 to 21 show a number of vessels used in different trades in all of which material is subjected to the action of steam for some purpose or another.

Bone Boiler.

Fig. 17 is a Bone Boiler. Bones are usually first prepared by soaking in dilute sulphuric acid. This is washed away before charging the bones into the bone boiler, but a certain amount of the fat and acid remain and cause rapid internal wasting of the plates.

Digester. **Vulcanizing Pan.**

Fig. 18 is a Digester, as used in a Candle Factory, and Fig. 19 is a Vulcanizing Pan. There are no features of special interest about the vessels themselves; they are both quite plain cylindrical vessels, but they illustrate two different

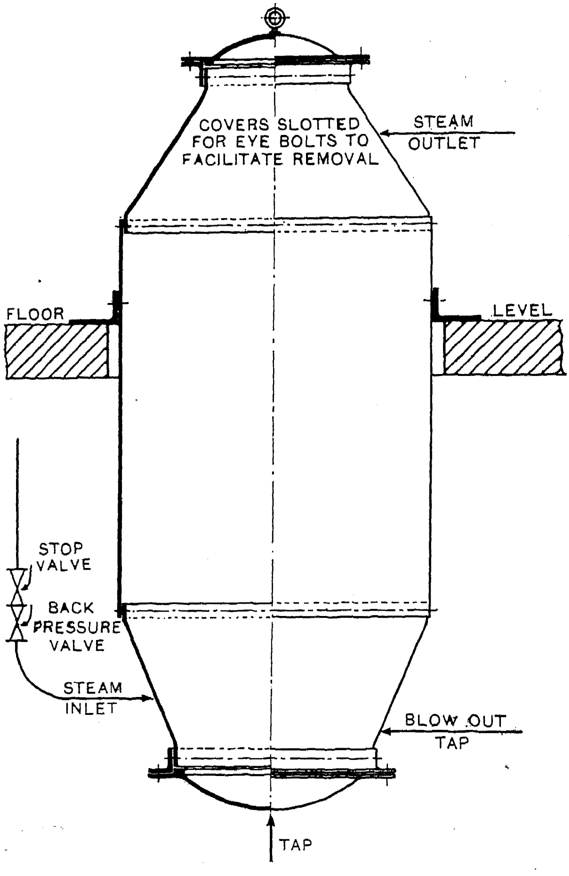


Fig. 17

methods of securing the cover. The cover of the digester is slotted to receive hinged bolts, while that of the vulcanizing pan is secured by means of a "Bayonet" ring. In this design of cover the tightening screws are carried in a "Bayonet" ring which engages with lugs on the vessel, and before tightening up the screws it is important to see that the lugs on the ring

"Bayonet" Ring.

engage with those on the vessel. As this is not readily seen it is advisable to place marks on the edge of the ring and on the body of the vessel to show when the "Bayonet" ring is in the correct position for tightening the screws.

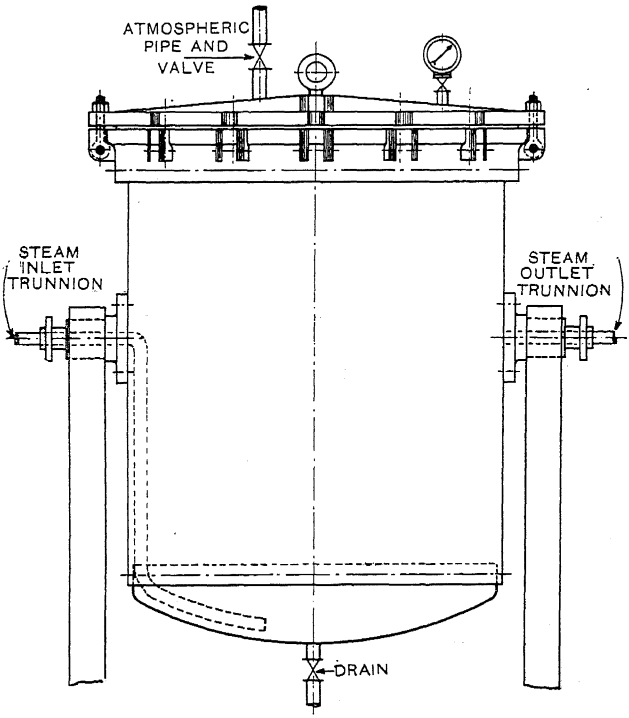


Fig. 18

In Figs. 20 and 21 are shown two vessels which, in addition to being filled with steam under pressure, are fitted with paddles or stirrers, so that the contents may be kept in motion. Fig. 20 is a Brewery Converter, and Fig. 21 an Autoclave. All such vessels, where internal paddles are used, are subject to considerable wear owing to the continual movement of the contents over the plates, and autoclaves are, in addition, often subject to rapid internal corrosion about the level of the surface of the liquid.

Brewery Converter. Autoclave.

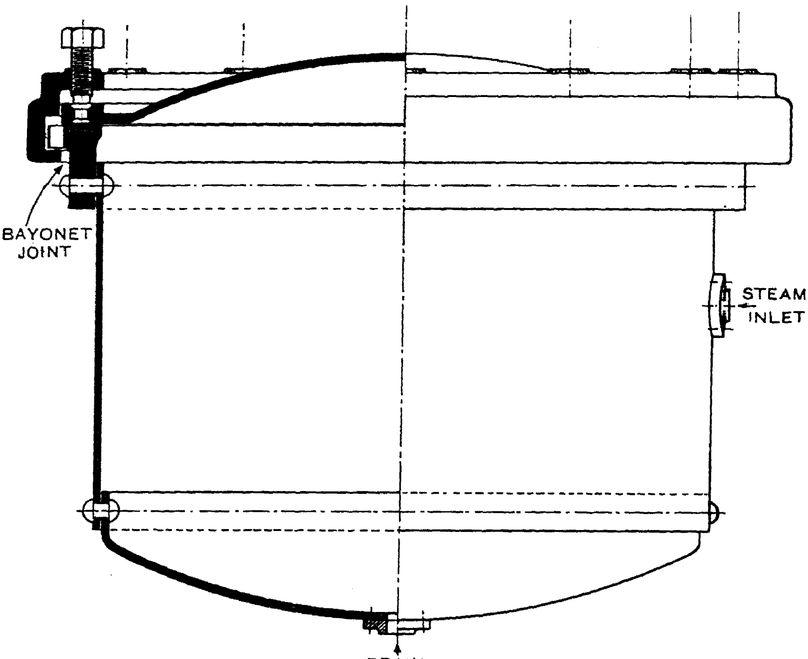


Fig. 19

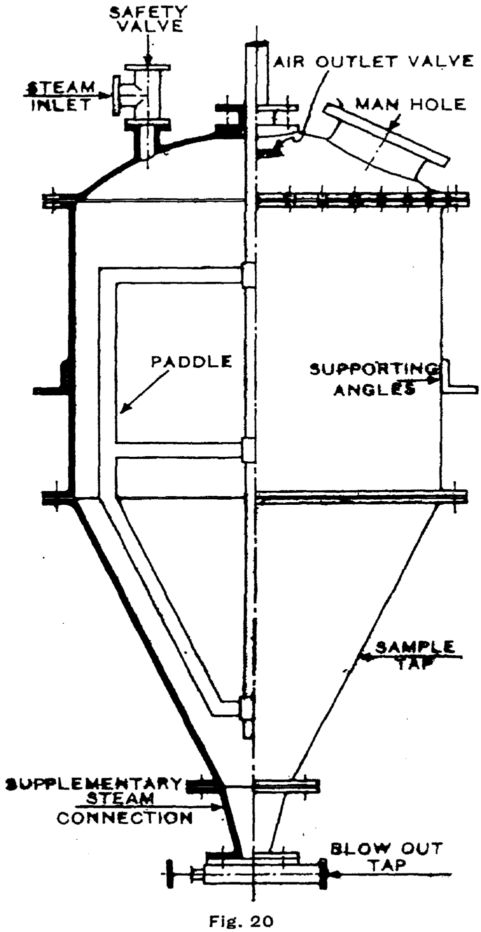

SAFETY VALVE
STEAM INLET
AIR OUTLET VALVE
MAN HOLE
PADDLE
SUPPORTING ANGLES
SAMPLE TAP
SUPPLEMENTARY STEAM CONNECTION
BLOW OUT TAP

Fig. 20

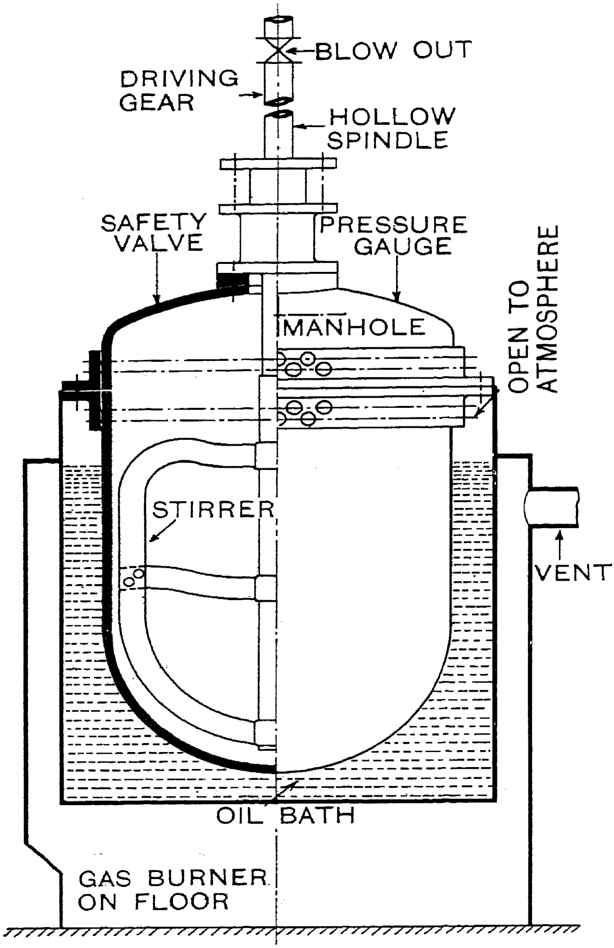
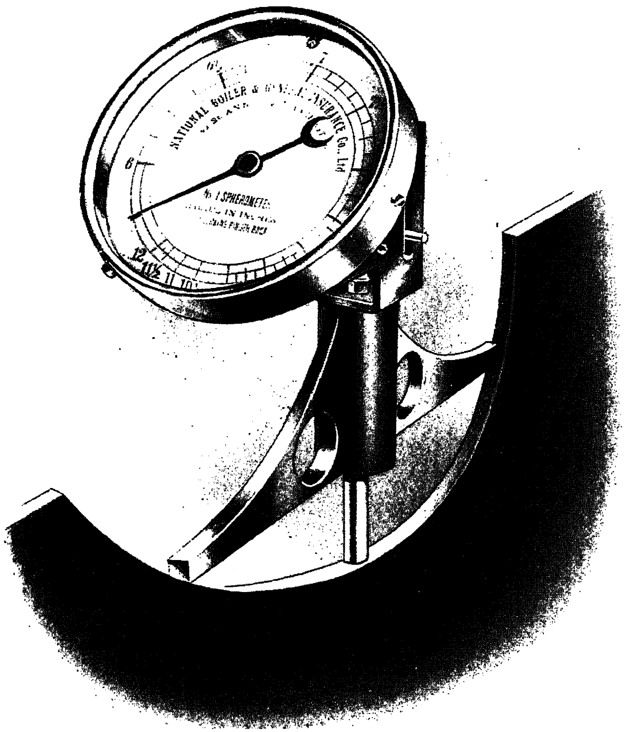

BLOW OUT
DRIVING GEAR
HOLLOW SPINDLE
SAFETY VALVE
PRESSURE GAUGE
MANHOLE
OPEN TO ATMOSPHERE
STIRRER
VENT
OIL BATH
GAS BURNER ON FLOOR

Fig. 21

Steam Jackets.

In another large class of steam vessels materials are heated by steam but without direct contact. This is effected by means of Steam Jackets. STEAM JACKETS.

The design of steam jacketed vessels to withstand pressure involves a number of interesting problems. The outer vessel is usually of spherical or cylindrical shape, and is subject to internal pressure ; its proportions may therefore be determined by means of the ordinary rules as for boilers. The internal vessel, however, is subject to external pressure, and in many cases requires staying to prevent collapse. Frequently the inner pan is of copper and is comparatively weak to resist collapse. Jacketed Pans.



"NATIONAL" Spherometer.

Fig. 22

The NATIONAL Boiler and General Insurance Co. Limited, Manchester.

Distortion of Inner Pan.

The spherical shape is the strongest, but it must be borne in mind that such vessels are very liable to become distorted, and any deformation from the true spherical shape weakens the vessel and greatly increases the liability to collapse. When inspecting such vessels, therefore, the Inspectors of the "National" Company make a practice of gauging the radius of curvature at different parts of the pan, using for this purpose an instrument called a "Spherometer," which has been specially designed for the purpose. This instrument is illustrated in Fig. 22, and consists of a straight bar of known length with a moveable central plunger connected by mechanism to the pointer on a dial. When the ends of the bar rest on a curved surface the movement of the plunger measures the versed-sine or depth of the arc, and by suitable graduation the radius of curvature corresponding to that versed-sine is read off direct from the dial.

"National" Spherometer.

Screw Stays for Jacketed Pans.

In many cases it is necessary to stay the inner pan to the outer vessel, and when that method of strengthening the inner pan is adopted, single widely scattered stays should not be used, but the weak cylindrical or flat surface should be

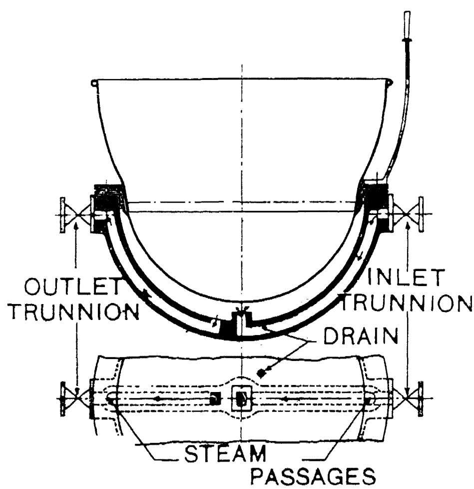


Fig. 23

divided up by means of complete rings or rows of screwed stays, just as in the case of a fire-box of a locomotive boiler. Single isolated stays are themselves liable to be heavily stressed, and their presence induces severe local stress in the plate and consequent local deformation.

Examples of Jacketed Pans.

In Figs. 23, 24 and 25 are shown a number of common forms of Jacketed Pans. The spherical form of inner pan, as shown in Figs. 23 and 24, is frequently strong enough to withstand external steam pressure without staying, but when the sides are cylindrical and the bottom comparatively flat staying is usually necessary.

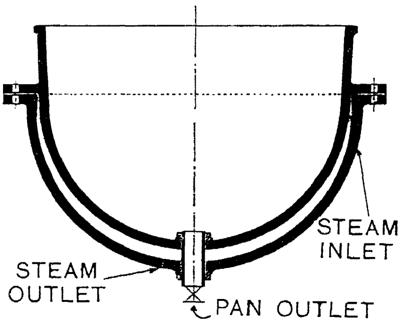


Fig. 24

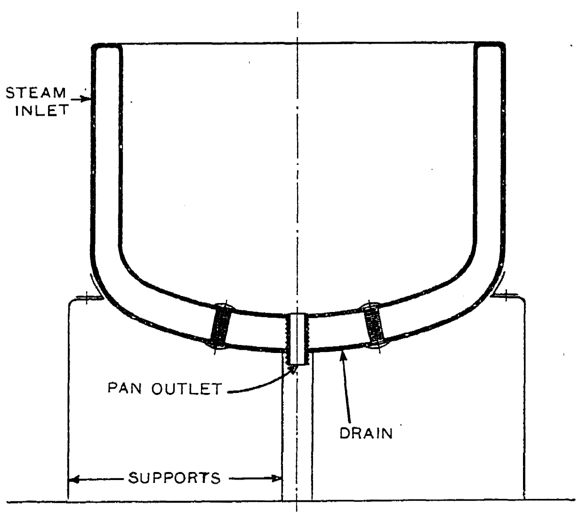


Fig. 25

It is usual to connect the inner and outer pans by means of a flanged joint, and it is important that the inner pan comes close up to the abutment at this part. A considerable overhang as M in Fig. 26, forms a weak point and aggravates any tendency there is for the inner pan to rise up and turn inside out.

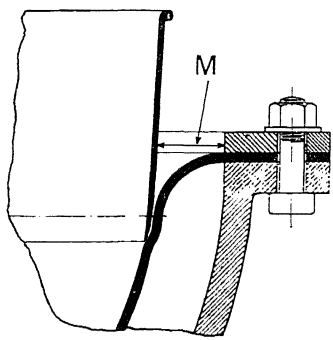


Fig. 26

Cylindrical Jackets.

Fat Melter.

Disinfector.

Examples of vessels having cylindrical jackets are given in Fig. 27, which illustrates a vessel used for melting up fat, and Fig. 28, which is a Disinfector.

Unless the pressure is very low such jackets almost always require staying, and the stays should be arranged in complete rings pitched about 7 to 10 inches apart. The stays should be screwed with a fine thread and both ends riveted over.

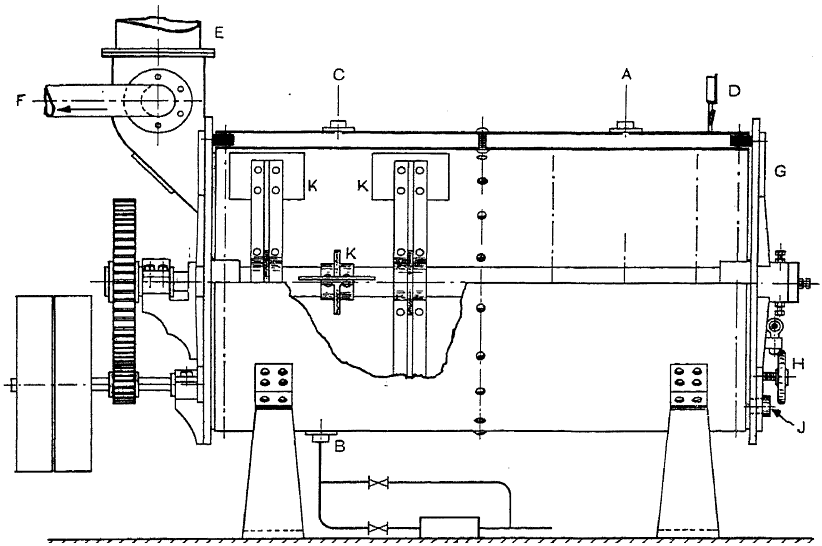


Fig. 27

A—Steam Inlet to Jacket.
B—Jacket Drain with Trap and By-pass.
C—Safety Valve.
D—Pressure Gauge.
E—Filling Hopper to Chamber.
F—Vent Pipe.
G—Door to Chamber.
H—Outlet Door in Chamber.
J—2 inch Fat Outlet in Door.
K K—Stirrers.

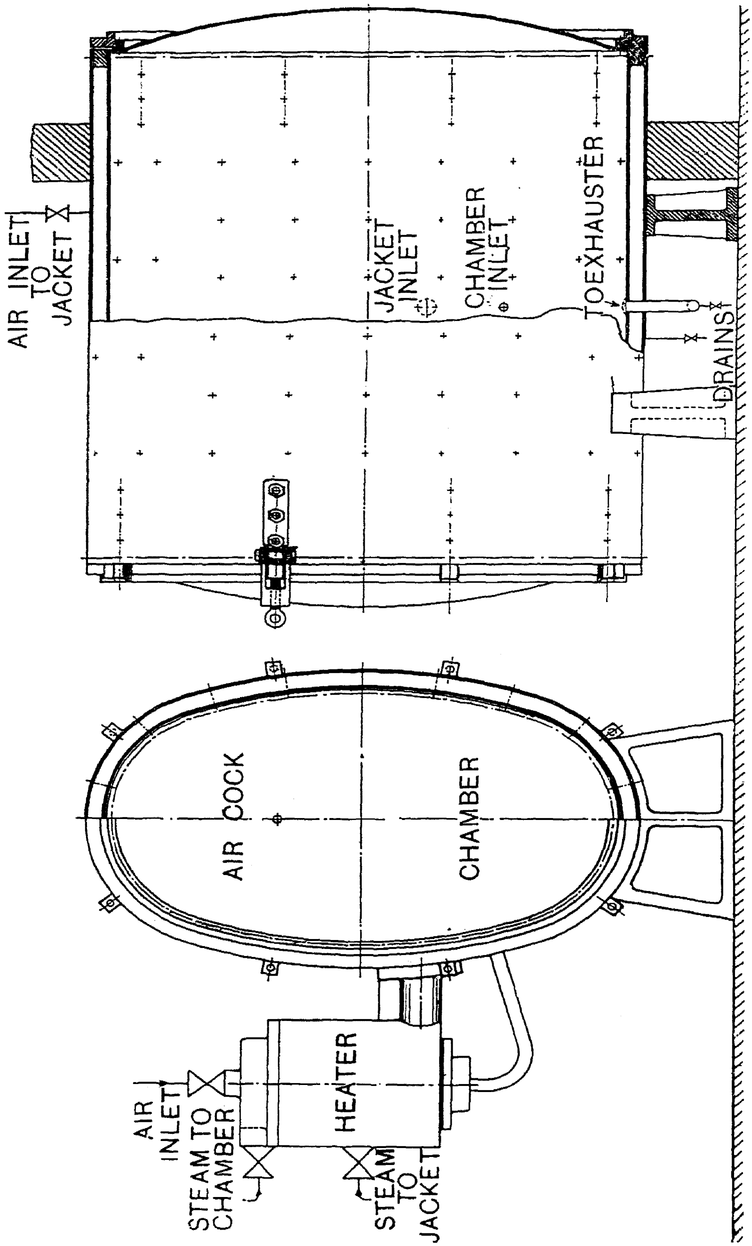
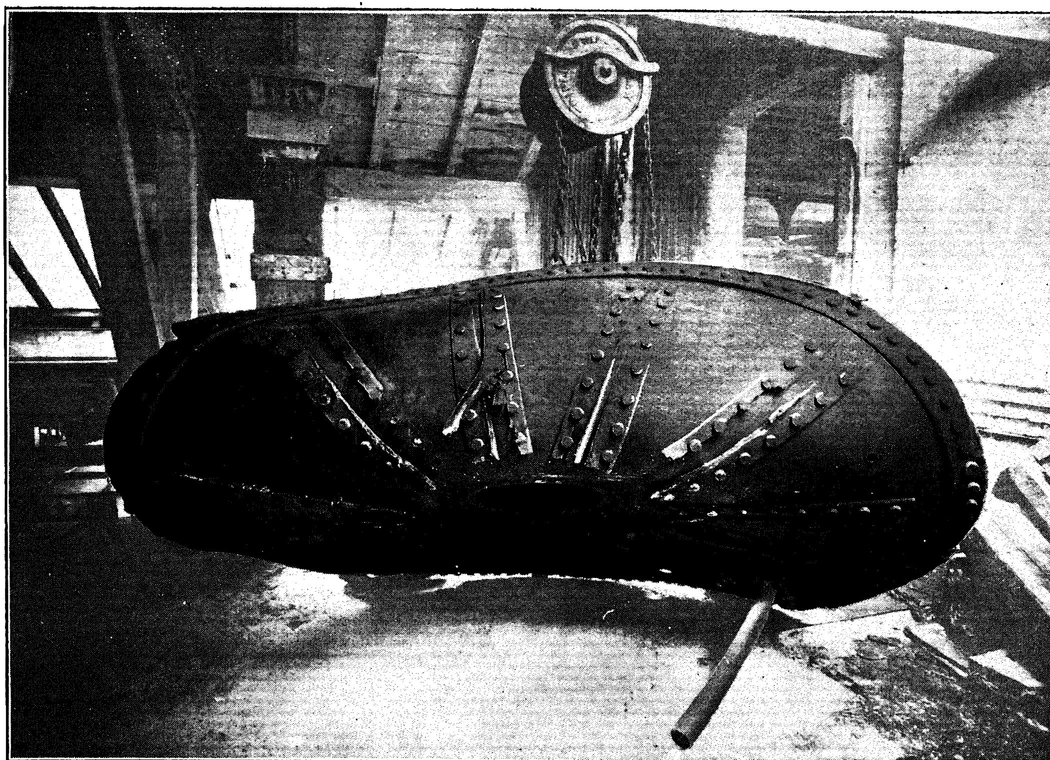
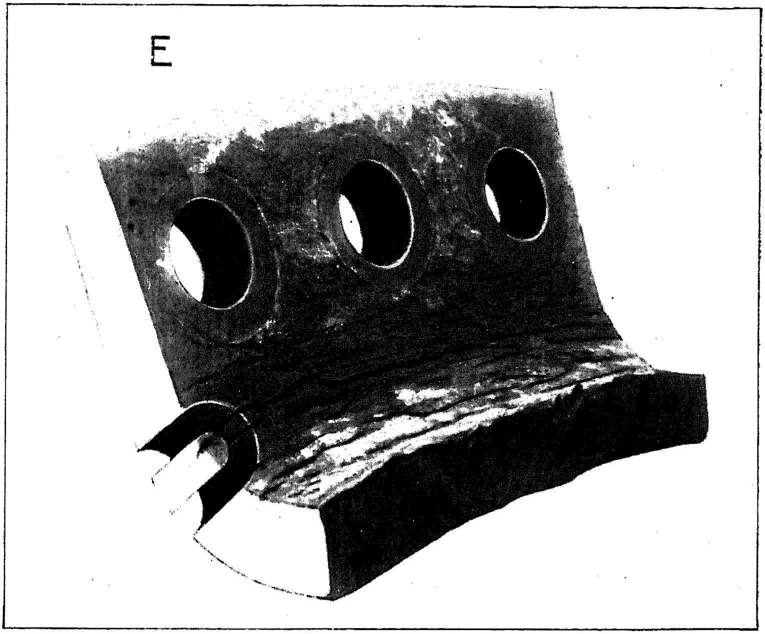


Fig. 28

The NATIONAL Boiler and General Insurance Co. Limited, Manchester.



Flat End of Exploded Vessel showing Fractured Gusset Angles.
Fig. 29



Grooved Plate Drilled with Core Drill.

Fig. 30

Gusset Stays.

Flat ends of large vessels are frequently stayed with gussets. Such gussets are secured to the end plates by means of angles and owing to the "breathing" action which takes place, grooving frequently occurs in the roots of the angle bars or through the line of rivet holes. **GUSSET STAYS.**

Fig. 29 is a photograph of the flat end of a vessel 8 feet in diameter working under a pressure of 60 lbs. per sq. inch, which exploded owing to the support becoming weakened as the result of grooving and cracks in the gusset angles. **Fractures in Gusset Stays.**

When cracks of this nature are first seen in the root of a flanged plate or angle bar it is often necessary to drill the plate before the depth of fracture can be determined, and for this purpose a "core drill" is the best tool to use. Core drills remove a small core from the fractured plate or bar, which core can then be closely examined and the depth of defect ascertained. Fig. 30 shows a grooved end plate which has been drilled through the grooved part and a core taken for examination. **Core Drill.**

Vessels Heated by Coils.

A considerable number of vessels, used for evaporating liquids at low pressure, are heated by internal steam coils and in several cases such vessels have been burst owing to the coil being defective and allowing high pressure steam to blow into the vessel. An illustration of this class of vessel is given in Fig. 31, which shows a Wort Copper as used in Breweries. **VESSELS HEATED BY COILS.**

A serious accident to a vessel heated by means of an internal coil is described in Board of Trade Report No. 2386. From the evidence given it appears that a brazed joint in the copper coil drew out, allowing the contents of the coil, consisting of hot water under pressure, to enter the vessel, which **Explosion Due to Defective Coil.**

rapidly filled with steam at a higher pressure than it was able to withstand. The cover of the vessel burst, scattering the contents and unfortunately scalding an attendant so severely that he died.

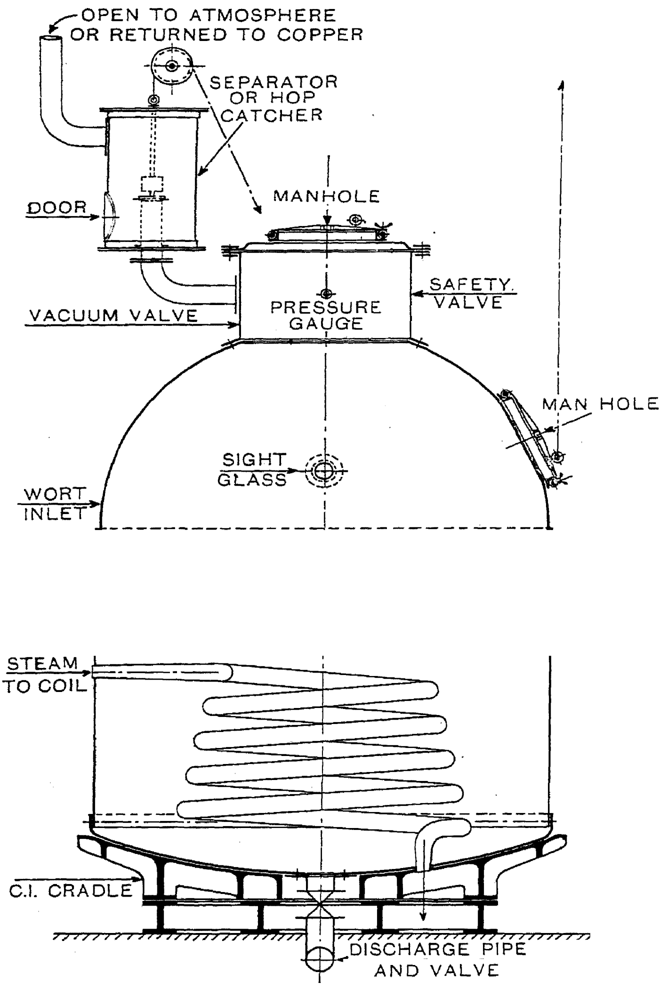


Fig. 31

Stills.

Stills are used for evaporating liquids in the preparation and refining of oils, varnish, spirits and various by-products in a large number of trades. They vary greatly in size and shape, but are commonly of light construction, being intended to work at a low pressure. They are usually connected to a condenser and in many cases the vapour is drawn through the condenser by means of a vacuum pump. Under normal STILLS.

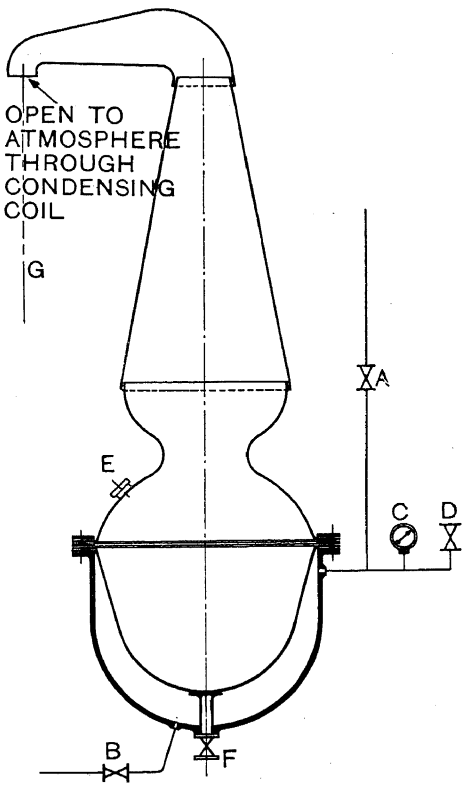


Fig. 32

A—Steam Inlet Valve.
B—Drain to Trap.
C—Pressure Gauge.
D—D.W. Safety Valve.
E—Sight Hole closed by Screwed Cap
F—Pan Outlet Valve.
G—Condensing Coil, open to Atmosphere.

conditions of working, therefore, such stills work at approximately atmospheric pressure, and they are not constructed to withstand either internal pressure or vacuum. Two different forms of Still are shown in Figs. 32 and 33.

Collapse of Still.

Many accidents with stills have been due to the condenser coil becoming blocked with the result that pressure accumulated in the still, or that a vacuum was formed which caused the vessel to collapse. Collapse of a still is illustrated in the photograph reproduced in Fig. 34.

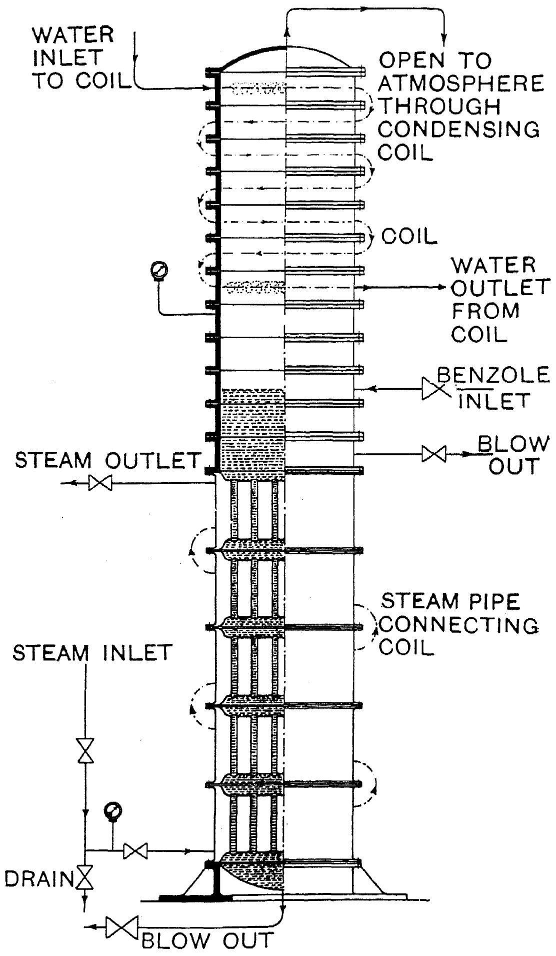
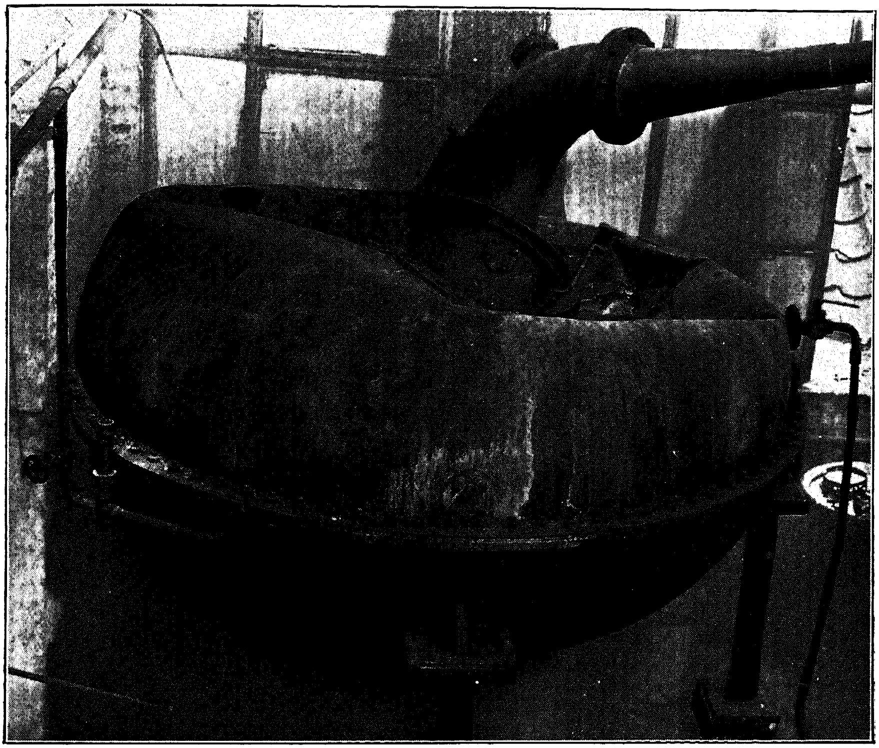


Fig. 33



Collapse of a Still.

Fig. 34

Experience shows that stills are sometimes burst through over-pressure owing to the outlet becoming choked. An instance of such an accident is to be found in Board of Trade Report No. 2177. This Report refers to a Cast Iron Still, externally fired, the vapour outlet from the still passing to a condensing coil through which it was drawn by a vacuum pump. Owing to the contents of the still having boiled over, the coil became blocked with solid condensed substance. The still was thus converted into a closed vessel and further application of heat resulted in an increase of pressure which eventually burst the cover. This explosion unfortunately resulted in the death of one person and injury to two others.

Outlet from Still Becoming Choked.

Such an accident as the one cited above would have been prevented if the still had been fitted with a safety valve *of adequate size and in good working order*, but that in many cases is difficult to achieve. If there had been a safety valve on the vessel it would quite likely have become choked when the contents boiled over, and unless taken apart and cleaned at frequent intervals and tested every few hours such a fitting would afford no adequate protection. As a precaution against such an accident happening again the bolted cover was replaced by a hinged lid which would lift in the event of any dangerous pressure being attained.

Difficulty of Avoiding Risk of Over-Pressure.

Decoudun Ironing Machines.

Ironing Machines are commonly constructed of cast iron and their strength requires careful consideration. They consist of a cast iron cylinder with a kidney-shaped bed underneath, both cylinder and bed being steam-heated (Fig. 35). The cylinder is usually of ample strength, but the bed is often stayed by cast iron pillars or ribs connecting the opposite surfaces and these ribs are liable to fracture. Such castings as the beds of ironing machines require to be carefully designed with the object of ensuring a uniform thickness of metal with well rounded corners at all junctions.

IRONING MACHINES.

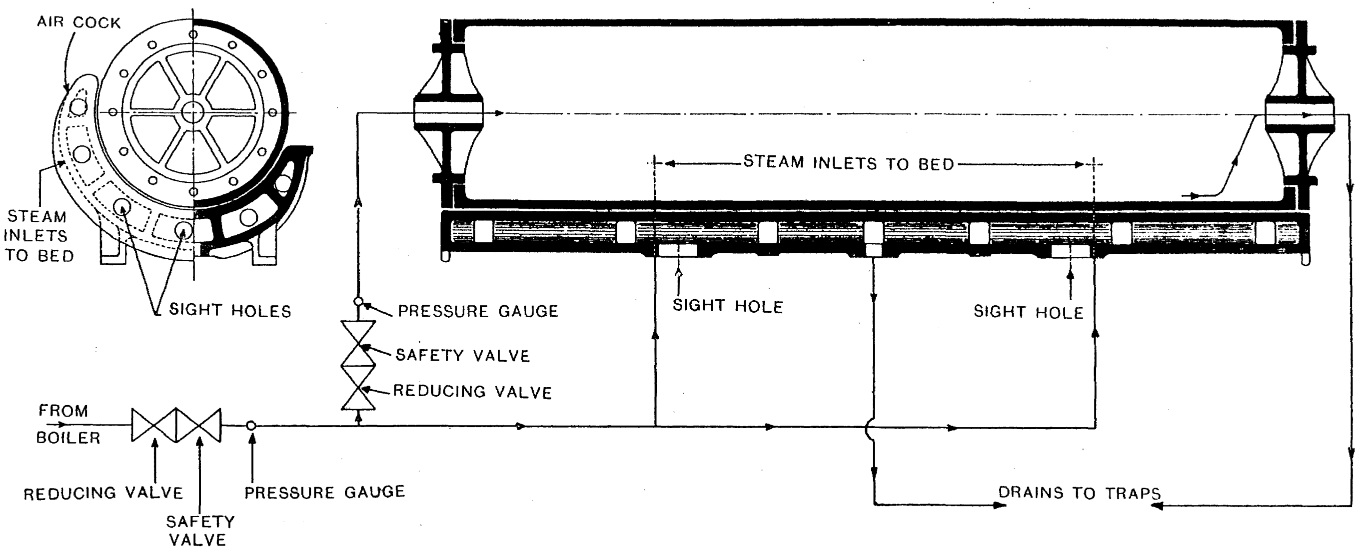
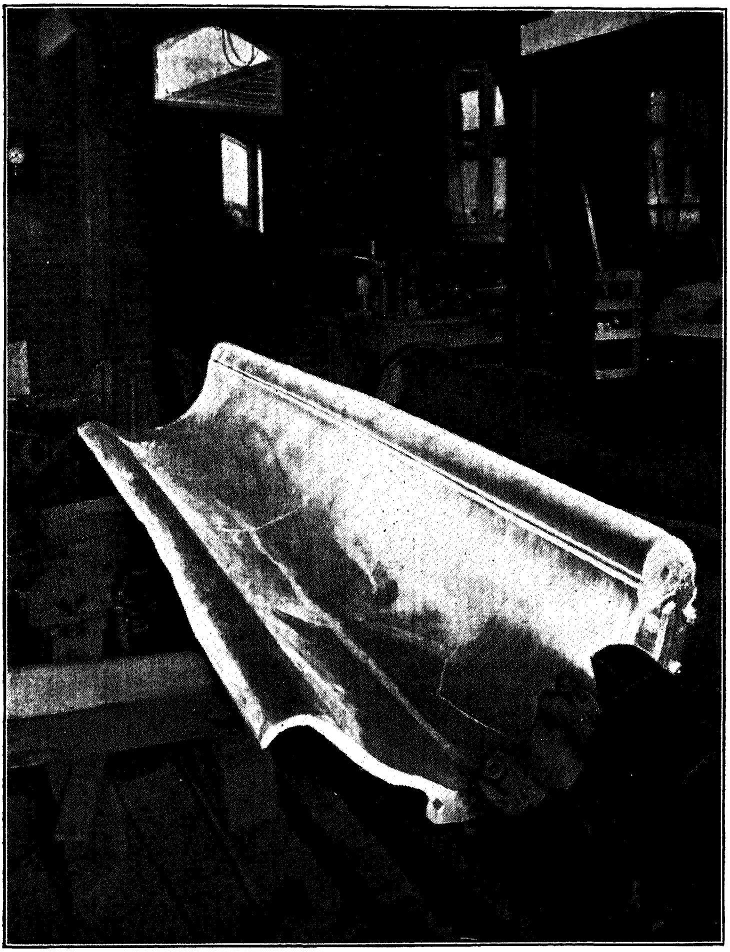

AIR COCK
STEAM
INLETS
TO BED
SIGHT HOLES
PRESSURE GAUGE
SAFETY VALVE
REDUCING VALVE
FROM
BOILER
REDUCING VALVE
SAFETY
VALVE
PRESSURE GAUGE
STEAM INLETS TO BED
SIGHT HOLE
SIGHT HOLE
DRAINS TO TRAPS

Fig. 35



Explosion of Ironing Machine Bed.

Fig. 36

A number of explosions of ironing machines have been investigated by the Board of Trade under the Boiler Explosions Acts. Fig. 36 is reproduced from a photograph of an exploded ironing machine by which three persons were scalded.

Explosion of Ironing Machines.

The Board of Trade Commissioners have expressed the opinion that the beds of Decoudun Ironing Machines should be hydraulically tested annually to twice the working pressure Hydraulic test is important in the case of a vessel of this description as the steam space is so narrow as to render internal examination difficult. Some provision for internal examination is made by means of sight holes or removable end covers, and by using a light fixed on the end of a long stick most of the internal ribs can be seen. As, however, some of these ribs may be three or four feet distant from the observer, it is evident that fine fractures may easily be missed. The practice of the "National" Company is to make careful gaugings of the deflection of the bed under hydraulic test or under steam test, and from the result of these gaugings the condition of the internal ribs and of the casting generally is estimated, and its suitability to withstand internal pressure determined.

Hydraulic Test of Ironing Machines.

Drying Cylinders.

The Drying Cylinders used in connection with fabrics, in Print Works, Finishing Works and the like are often constructed of thin sheet iron, tinned or galvanized, with cast iron ends (Fig. 37); they are commonly worked at 5 to 10 lbs. pressure. These cylinders are subject to considerable corrosion, both internal and external, and as the metal is originally very thin they rapidly become structurally weak and unable to withstand even a low pressure.

DRYING CYLINDERS.

Steam is admitted and water of condensation drained away through the trunnions. The usual method of draining is by an internal pipe or a scoop A which lifts the water until it runs out through a drain B at the centre. This scoop and

Corrosion of Scoop.

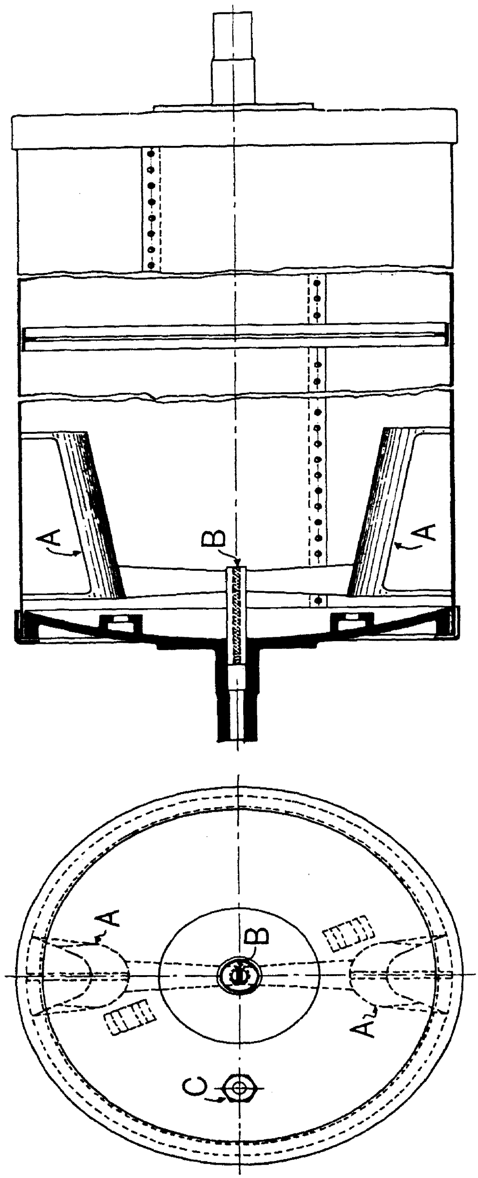


Fig. 3

B—Trunnic C—Ai

drain pipe often corrode through and become inoperative, with the result that a considerable weight of water lies in the bottom of the cylinder straining the thin plate and its attachment to the ends.

Safety Valve.

The branch steam pipe conveying steam to a set of drying cylinders should always be fitted with a reliable dead weight safety valve, so as to protect the cylinders from bursting through over-pressure, and each cylinder should be fitted with air valves to prevent the cylinder from collapsing owing to the formation of a vacuum. Two air valves are usually necessary and these should be fitted on the ends in diametrically opposite positions, so that if one is under water the other is free to operate.

Air Valve to Prevent Collapsing.

Home Office Recommendations.

Drying cylinders occur somewhat frequently in Board of Trade Reports, and recently the Home Office have formulated the conditions which must be complied with if exemption from Annual Hydraulic Test is desired.

These conditions, briefly stated, are as follows :—

(1) That the cylinders are periodically examined by a competent person.

(2) That each set of drying clyinders shall be provided with a reducing valve (unless the cylinders are constructed to withstand the full boiler pressure), a safety valve and steam gauge.

(3) That the safety attachments shall be maintained in efficient working order.

(4) That the total area of the safety valves on any set of drying cylinders is not less than 1·25 to 1·5 times the total area of the inlet valves.

(5) That a record giving in detail the result of the periodical examinations is kept and is available for examination by H.M. Inspector of Factories.

INSPECTION OF STEAM VESSELS.

Advisability of Delegating Inspection to "National" Company.

In the majority of cases where enquiry into an explosion is made it transpires, or the impression is left on one's mind, that there has been no systematic inspection of the vessel by the owner or his employees. The fact is that inspection is a duty which is much better delegated to an outside body, such as The National Boiler and General Insurance Co. Ltd., who make that their principal business and visit the premises for that particular purpose. The staff at a works are inevitably preoccupied with the manufacturing operations, with the *Product* of the factory, and their routine duties do not allow them to give more than casual attention to the *Plant*.

Importance of Systematic Inspection.

The "National" Company on the other hand concerns itself first and last with the safety of the plant. It employs Engineers as Inspectors, trains them in the inspection of steam plant, and institutes a regular and systematic examination of all vessels covered by its policies. After each Thorough Examination (*i.e.*, Internal and External), a written report is sent stating the condition in which the vessel was found, and making any recommendations which may appear necessary to ensure safety.

Inspection and Insurance of Vessels under Pressure.

List of Typical Vessels which should be placed under Inspection Service and Insured against Explosion.

Autoclaves.
Air Receivers.
Air Heaters.
Ammonia Vessels.
Brewery Converters.
Baking Ovens.
Bleaching Kiers.
Bone Boilers.
Blow-down Tanks.
Brick Hardening Chambers.
Cylinders for Compressed Gas.
Calorifiers.
Calenders.
Cask Washers.
Creosoting Vessels.
Chaff Steamers.
Clothes Pressing Machines.
Concentrators.
Drying Cylinders.
Disinfectors.
Digesters.
Evaporators.
Enamelling Plant.
Feed Tanks.
Feed Water Heaters.
Fermenting Vessels.
Fat Melters.
Gas Cylinders.
Gas Works Vessels.
Gas Plants.
Hay Steamers.
Hot Tables.
Hot Water Heating Systems.
Ironing Machines.
Impregnating Cylinders.
Jacketed Pans.
Kiers.
Kettles.
Liming Vessels.
Liquor Vessels (Gas Works).
Matrix Drying Tables
Milk Dryers.
Noggeræth Vessels.
Oil Hardening Vessels
Ovens.
Purifiers.
Potato Ovens.
Pitch Coolers.
Rag Boilers.
Retorts.
Stills.
Sulphate Plant.
Steam Pipes.
Steaming Vessels.
Suction Gas Plants.
Steam Jackets.
Tar Receivers.
Timber Seasoning Vessels.
Tar Stills.
Tubular Air Heaters.
Urns.
Vulcanising Pans.
Vulcanising Moulds.
Vegetable Cookers.
Vacuum Pans.
Vaporisers.
Wort Coppers.
Waste Heat Accumulators.

It is important to note that

The Boiler Explosions Act, 1882,

applies to "any closed vessel used for generating steam, or for heating water, or for heating other liquids, or into which steam is admitted for heating, steaming, boiling, or other similar process."

The Economical Working of Power Plants

WHEN a power user finds it necessary to renew or alter his power plant, or to put down entirely new plant, a number of technical and financial questions arise, in reference to which the special knowledge and experience of the Engineering Staff of this Company is exceptionally valuable. This special experience is at the disposal of our insurers, and the Company is prepared to advise fully on Steam Boilers and Engines, Mill Gearing, Gas and Oil Engines and Gas Producer Plant, Electrical Driving and Power Plant generally.

When Replacing, Altering, or Adding to

Existing Power Plant,

it is, as a rule, the best course to ask the Company to investigate and report upon existing conditions, and to advise as to the changes which can most profitably be made.

Where the question involved is that of an

Entire New Power Plant

The Company is prepared, in the first place, to report upon alternative schemes of driving and to advise as to the scheme which is best adapted to meet the requirements of the case.

Preparation of Specifications, Obtaining Tenders, Checking Working Drawings, Examination during Construction of

New Steam and Gas Power Plant, and Electrical Plant.

New Boilers, Pipes, Economisers, Superheaters, Engines, Turbines, Mill Gearing, Pressure and Suction Gas Plant, ——Gas Engines, Dynamos, Motors, Wiring, &c.——

Investigations as to the Working of Unsatisfactory Power Plants, Analysis of Feed Water, Fuel, Flue Gases.

Special Economic and similar Tests made.

The "National"

Patent Fusible Plugs.

These Fusible Plugs are a most valuable safeguard against damage arising from shortness of water, and are made for all kinds of internally-fired Boilers.

These Plugs embody all improvements suggested by the extensive experience of the Company.

Special attention has been given to the Plug for High-Pressure Boilers; the fusible metal is entirely enclosed, and thus protected from deterioration by either the furnace gases or the water.

All these Plugs are made to Standard Gas Threads on the Seatings, and each Plug is tested to 400 lbs. per square inch.

Improved Valve Seated Plug.

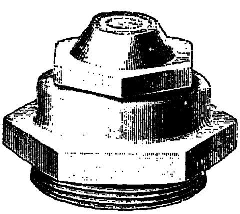


Fig. 6.

Low-Pressure Type.

Screwed
$\frac{3}{4}$in., 1in., 1$\frac{1}{4}$in., 1$\frac{1}{2}$in., 2in.
Gas Thread on the Seating.

Improved Valve Seated Plug.

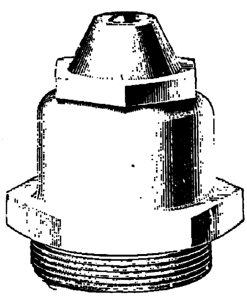


Fig. 8.

High-Pressure Type.

Screwed
$\frac{3}{4}$in., 1in., 1$\frac{1}{4}$in., 1$\frac{1}{2}$in., 2in.
Gas Thread on the Seating.

Improved Screw Cone Loco Plug.

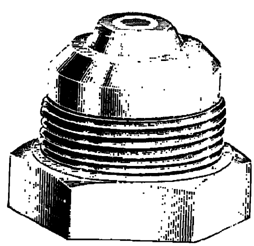


Fig. 12 or 15.

For Boilers of the Locomotive Type.

Screwed 1in., 1$\frac{1}{4}$in., 1$\frac{1}{2}$in.
Gas Thread on the Seating.

For further particulars see detailed Price List.

The NATIONAL Boiler and General Insurance Co. Limited, (Sales' Dept.),
St. Mary's Parsonage, Manchester.

Useful Articles supplied by the Company.

Prices on application.

Fusible Plugs.—The "National" Patent Fusible Plug. Safeguard against accidents from low water. Recommended for all internally-fired boilers.

Taps and Valves.—For the standard test gauges and indicators used by the Company's Inspecting Engineers.

Test Gauges.—Duplex Finger Test Gauges as used by our Inspecting Engineers for testing Pressure Gauges.

"National" Patent Enclosed Safety Valves.—Made in two classes. (1) For Hot-water Boilers. (2) For Steam Vessels working up to 50 lbs. per square inch.

Automatic Air Valves for Steam Pipes.—Automatically admit air into Steam Pipes whenever there is a vacuum in the pipes, and close immediately steam is turned on.

Safety Test Burner for Gas Plants.—An improved fitting for easily testing the quality of gas.

Overalls.—For Boiler Cleaners, etc., as used by our Inspecting Engineers, and adopted by Railway Companies. Self-measurement forms on application.

Figure Plates.—For attachment to fronts of Boilers, etc., to facilitate reference and prevent confusion.

"National" Patent Economiser Circulators.—For preventing external wasting of economiser pipes, by raising the inlet temperature of water entering economiser. (Full particulars and prices on application).

Salinometers and Copper Jars.—For testing the density of feed water.

Mercurial Pressure Gauges.—For low-pressure vessels such as Stills, Drying Cylinders, etc.

Thermometers for Bakers' Ovens.—Designed for use with Steam Baking Ovens.

Water Gauge Glass Guards.—Constructed in accordance with the requirements of the Factory and Workshop Act and Coal Mines Act.

The NATIONAL Boiler and General Insurance Co. Limited, (Sales' Dept.),
St. Mary's Parsonage, Manchester.